NEW OBSERVATIONS ON MOULTING AND MATING IN TARANTULÆ

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Moulting and especially mating in spiders are now fairly well known owing to the work of several investigators. Little that is really new could be added to the general picture except variants of the process, due to specific differences. Nevertheless there are a few points which still require elucidation, and which, if properly understood, may open up new problems for investigation.

The spiders which I had under observation are two species of West Indian tarantulæ, *Cyrtopholis jamaicola* Strand from Jamaica and *Phormictopus cancerides* (Latreille) from Haiti. Most of the observations refer to *Cyrtopholis* which is the smaller of the two. It is by no means common, but owing to importation of fruit from Jamaica one may get occasionally specimens from wholesale fruit dealers. *Phormictopus* is a much larger, highly irritable spider reputed to be poisonous to man and always ready to strike at the slightest provocation, even at a jet of water poured three or four inches in front of it. I was able to obtain over fifty specimens of various ages and a cocoon with eggs through the courtesy of Dr. Bond who spent several weeks in scientific studies in Haiti. So far, my observations on *Phormictopus* are limited to general behavior and moulting. Although both species are burrowers in the ground and soil was provided for them in the glass jars and terraria in which they are kept, none of them has made an attempt to dig a hole in captivity. Many of the *Phormictopus* disturbed the sand, heaping it up, but without starting anything like a burrow. During the day they sit quiet, but after dark one finds them more active, walking or climbing.

Three specimens of *Cyrtopholis* were obtained in autumn 1930 and kept under observation. One of them was undoubtedly a young individual and proved later to be an immature female, when it was sacrificed for other studies in 1932 and found, on

dissection, to possess ovaries. The other two specimens had the appearance of mature females, hairy, light brown in color. I particularly stress this point on account of their subsequent history which caused not a little merriment in our laboratory when they finally proved to be males after the shedding of their last skin in August, 1931. Not even the slightest indication of their sex could be detected previous to the last moult, no swelling either of the terminal joint of the pedipalps or of the distal end of the first tibiæ where the powerful hooks are prominent in mature males. It is well known that in all dipneumone spiders the male sex may be easily recognized in the penultimate instar characterized by the swollen condition of the terminal joint of the pedipalps, while almost all other characters are still of the juvenile or feminine type. Not so in *Cyrtopholis* and *Phormictopus*. The lack of any external difference in appearance between a mature female and an immature male makes one curious to know in how many instances the description of new species of tarantulæ had for type an immature male instead of, as assumed, a mature female? I call this to the attention of arachnologists to guard them against possible and serious error, because with the exception of half a dozen species of dipneumone spiders studied from the first to the last instar, we do not know the external characters by which the sex could be recognized in immature individuals.

But let us return to our observations. The three specimens of *Cyrtopholis* were kept in round glass jars 9 inches in diameter and fed on grasshoppers, cockroaches, crickets and beetles. The specimen which we nicknamed "Isabel" subsisted on the above food until August 22d, 1931, when for the first time food was refused. The spider became sluggish and did not touch food again until after the moult. On the evening of August 27 it started weaving a sheet of silk from 1 to $2\frac{1}{2}$ inches from the bottom of the jar, attaching it to the walls in many places. The sheet, or as I would like to call it, the "moulting bed" was completed on the morning of August 28. It extended over three quarters of the circumference of the jar, consisted of closely woven threads and had the texture of a strong, yet soft sheet. Between 1 and 2:30 P.M., the spider turned on its back and lay

motionless, with legs sprawling, holding on to the web by the claws of the first and fourth pairs of legs. Figure 1 is a reproduction of a photograph made a little after three o'clock in the afternoon with an exposure of 1 minute, proving that the spider did not move in the slightest degree. At 4:15 the old skin began to split, first along the anterior edge of the carapace, then along its sides. Next the petiolus split on each side, its tergite remaining attached to the carapace. The abdomen split now on both sides in straight lines for about $\frac{2}{3}$ of its length. Now, still lying on its back with legs sprawling, the spider extracted first its cheliceræ which were white on their prolateral surface and had also perfectly white fangs. All through the following performance the old carapace remained in place, completely hiding from view the new carapace. By this time the position of the spider was somewhat shifted, so that it lay almost on its right side. The second and third pairs of legs twitched irregularly, but the first and fourth were still holding on to the moulting bed, exerting an occasional pull on it. Slowly the body became exposed to view through the slit on the left side. At 4:30 the spider began to contract its legs more or less rythmically, now pushing, now pulling with its femora. These contractions were of brief duration and were followed by considerable intervals of rest. Thus the femora were freed of their old skin, while the rest of the legs still remained inside it. The process of pushing and pulling continued for a while until the greater portion of the legs was freed. The hold on the web was now relaxed and the first pair of legs completely liberated. Next the palpi were freed. Then the fourth legs relaxed their hold on the web and the fourth femora extracted. With rythmic contractions all legs were pulled out and as they emerged from the old skin, they flexed in the knee-joint and the tibio-metatarsal joint to right angles. The abdomen was freed next. By now the spider was again flat on its back, but with legs flexed. It began to move slowly and laboriously by stemming its knees against the web and pushing the body forward. At 5:15 the spider was completely free of the old skin which was now removed to a jar of alcohol without disturbing the spider. At this time the color of the spider was pitch black with rufous hair on abdomen and legs.

Sternum and coxæ were black, the maxillary scopulæ red, but the maxillæ themselves, the fangs, the prolateral surface of the cheliceræ and the copulatory apparatus at the end of the palpi still white. The spider remained on its back under observation until 6:30 when observation was discontinued. At 7:15 the spider was found sitting on the web in a normal position, except that its legs were still flexed and held pressed tight against the body. The actual process of moulting took, therefore, at least five hours from beginning to end.

That the method of moulting, as described above, is the normal one not only for *Cyrtopholis,* but for *Phormictopus* as well, is apparent from the fact that I observed it in five cases in the former species and in 25 cases in the latter species. In all cases without exception a moulting bed was first woven and the spider lay motionless on its back. This took place not only in comparatively small jars, but in a large terrarium as well, the only difference observed being that the sheet is sometimes built slightly *above* the ground, but more often directly *on* the ground. It raises an interesting question as to how and where moulting is accomplished in nature? That it cannot be done in the burrow is evident. The spider must find a convenient place for its bed, moreover, one where it would not be exposed in its helpless condition to the attack of enemies, such as toads, lizards and digger-wasps. The creature remains in a helpless condition not only during the process of moulting, but for six or eight hours more, *i.e.*, until the fangs harden and change from white to black.

The color of the spider presents also an interesting feature. A recently moulted individual is almost entirely black. But as time goes on, the color of the hair fades and the spider appears brown or even light brown after several weeks.

"Isabel," who turned out to be a male, was now nicknamed "Ferdinand" and kept under continued observation. At 10:30 A.M., September 23, he started to build a sperm-web which he completed by 11 A.M. The web had the same appearance and structure as that of *Dugesiella hentzi,* described by me years ago. At one end it also had a concave semicircular edge. Figure 2 shows a photograph of the web with a drop of sperm hanging from its underside. As the spider constructed six sperm-webs in

the course of 9 weeks all on the same plan and pumped the sperm in the same manner, I shall describe the process from my notes of October 1, when the second sperm web was constructed by him in 20 minutes, between 11:25 and 11:45 A.M. As usual, the spider was lying on its back under the web stemming his knees against the bottom of the jar. The next action cannot be interpreted in any other way than a deliberate measurement of the exact distance from the semicircular edge, at which the sperm should be deposited. Lying on its back the spider moved slowly out from under the web, until the long hairs on his fourth coxæ were abutting against the edge. He does this by a to and fro movement of the body, until the erect hairs, at their base, are actually in firm contact with the edge of the web. The determination of the exact distance is of great importance in view of the final position on top of the web, in which the spider pumps the sperm into its palpi.

Having determined the distance in the above manner, the spider engages now simultaneously in two actions: (1) constant licking of the copulatory bulbs which he moves in and out of his mouth at the same time stroking them with his cheliceræ and (2) secreting from the genital opening a special fluid which he spread on the underside of the web by a lateral motion of the abdomen, pressing the genital opening against the silk. This fluid gives a white opaque color to the silk, adheres to it firmly and, apparently, has the sole function of creating a surface which is capable of holding a drop of sperm in suspension. The field covered by the fluid has the shape of a low trapeze with a base 1 cm. long and a height of 3 mm. This double occupation lasted until 12:16, when the spider stopped suddenly both motions, ejected a drop of sperm about 1/20th of a cc. and of opalescent pearly white color, climbed out from under the web on top of it, turned around, tapped the web from above with his palpi several times, as if trying to find the drop of sperm, brought the bulbs to the underside of the web over the semicircular edge and searched for the sperm for a while. After six or seven attempts he finally located the drop and began pumping it alternately with both palpi at a rate of 95 to 96 times per minute for each palp. The pumping was kept up for 1½ hours. It became slower

toward the end of this time. Finally the right palp alone was used. The spider now turned again, so that his head was in the direction opposite to the semicircular edge, and proceeded to destroy the web by pulling it with his legs and palpi and stuffing it into his mouth with his fangs.

As stated, this male constructed a spermweb and pumped sperm six times, namely September 23, October 1, 9 and 16, and November 2 and 30. In all cases the essentials of the process were the same, though some variation occurred. Thus on October 16, having ejected the drop of sperm, he crawled out in the usual manner to the top of the web, but instead of immediately turning around, for some time stroked the edge of the web with the middle joints of the long, posterior spinnerets. No silk was secreted and apparently the motion was one of orientation, for he tried to turn his cephalothorax as far as possible, without losing contact between the spinnerets and the web. After a while he stopped stroking the edge, turned round and started to search for the drop of sperm with his palps.

An attempt was made to mate "Ferdinand" with the other Cyrtopholis which was nicknamed "Sylvia." Naturally the mating did not succeed for the obvious reason that a few days later "Sylvia" moulted and proved to be also a male. But mating was successfully induced in another pair which belonged to the American Museum of Natural History. The process was practically the same as described by me for *Dugesiella* and need not to be further considered here.

There is, however, an important difference in the manner in which the sperm is pumped in *Dugesiella* and *Cyrtopholis*. If my observation was correct, *Dugesiella* ejects the sperm on top of the web and pumps it from below, through the web. *Cyrtopholis* attaches the drop *to the underside* of the web, more or less in the same manner as that described recently by Gerhardt for four other species of tarantulæ (Forschungen und Fortschritte, Berlin, 1933, Vol. 9, No. 9). It is possible that I made an error of observation, although at the time I felt certain that I made no mistake. At any rate the question cannot be settled until further observations are made on *Dugesiella*.

Moulting in *Phormictopus cancerides* was observed by me in some three dozen individuals at the close of the first instar and

in 25 cases of much older individuals of different size and age. The greatest deviation from the above described method occurs in the change from the first to the second instar. The spiderlings, between two and three hundred of them, emerged from the eggs in the middle of March, 1933. At that stage they are chocolate brown, with little hair, if any, two claws without a trace of claw-tufts and an eyegroup with small anterior median eyes and situated on a level with the carapace. No eyetubercle is yet developed, and the general appearance of the spiderling is rather that of a Ctenizid than of a Theraphosid.

In a couple of days the color of the spiderlings changes to black and in about a week moulting begins. No moulting bed is constructed, as the spiderlings still cling to the old cocoon. After the splitting of the old skin the spiderling gradually withdraws from it. Some lie on their back with legs sprawling, in preparation for the moult; some cling to the cocoon in any position they happen to be in; some climb a vertical wall and hang on to it while moulting. In several cases the moulting was not successful, either a leg or a spinneret being retained in the old skin which was then dragged about for several days. The spiderlings of the second instar have a distinctly blue color, have longer legs, are hairy and have the general appearance of a Theraphosid. The claw-tufts are well developed and 6 spatulate hairs are present on the dorsal surface of each tarsus. The anterior median eyes are larger and the eyetubercle is clearly defined, although as yet very low. Neither the first nor the second instar have the vicious disposition of the older specimens and neither threaten, nor attempt to strike. In nature they must be an easy prey to a number of enemies. In captivity they must be kept in individual jars and are easily fed on Drosophila. The species is quite common in Haiti, but the only security against extinction seems to lie in their fertility and longevity. Female tarantulæ live many years, males die soon after maturity. "Ferdinand" pumped sperm for the last time on the last day of November, 1931, and died of old age July 5, 1932, after refusing food for some time and with an abdomen shrivelled to a small fraction of its original size. A male *Phormictopus* lived several months after attaining maturity.

PLATE XVI

FIGURE 1. Male *Cyrtopholis jamaicola* Strand in the penultimate instar lying on his back on the moulting bed in anticipation of the last moulting process. Notice that his palps show no swelling of the terminal joint, characteristic in true spiders. Notice also that he is holding on to the web with the claws of the first and fourth pairs of legs. Photographed in a direct line from above.

FIGURE 2. Spermweb of the same male, constructed four weeks later. Notice at the left the concave semilunar edge and slightly to the right of it the drop of sperm. It may be located at the intersection of the lines shown in white ink. Photographed at an angle from above.